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Effects of a Transient Cancer Scare on Property Values: Implications for Risk Valuation and the Value of Life

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ABSTRACT

A transient cancer scare is presented as a rare opportunity to observe the effect of a perceived increase in risk on the price of residential property. The temporary nature of the perceived excess risk allows for the isolation of a risk premium from the change in housing prices, because prices decline during this natural experiment and return to normal when the cancer scare is proven to be unfounded. Value of life measures imputed from this risk premium are orders of magnitude lower than similar values obtained by studies involving other risk-dollar tradeoffs. The likelihood of death which is taken to be valued by the risk premium is much greater in this case than in other value-of-life studies, giving support to the notion that the aversion to risk is not directly proportional to the probability of harm.

Key Words: Risk Perception, Risk Premium, Value-of-Life.

INTRODUCTION

An epidemiological study made public in January of 1987 in Canada appeared to indicate that the incidence of cancer in two communities near Edmonton, Alberta, was 25% higher than in surrounding areas. It was later learned that this apparent elevation in cancer incidence was due solely to a simple arithmetic error in the conduct of the study. However, during the several months between release of the study and discovery of the error, the study gave rise to a public perception that living in the two communities, which had a combined population of 52,000, entailed an

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increased cancer risk compared to living in the rest of Canada. During this period, nationwide media coverage of the cancer scare was extensive. While no particular cause of the apparent increased cancer rates was ever identified, suspicions turned to the nearby petrochemical industries, whose emissions had caused prior concern. The cancer scare had a variety of adverse effects on the communities, among them a decrease in property values. The sale prices of residential property began to decline as initial findings of the (erroneous) study were made public, reached a nadir after the release and extensive media coverage of the study, and rebounded to near-prior levels when the error was revealed and disclosed (Guidotti, 1992). On average, the sale price of a representative type of home sold during the cancer scare declined by 5% or $4000.

This paper interprets the decline in property values as a risk premium and imputes a value of life measure from the price-risk tradeoff inherent in a decision to move to the communities in spite of a perceived excess cancer risk.

PUBLIC RESPONSE TO THE REPORTED ELEVATION IN CANCER INCIDENCE

The apparent elevation in cancer incidence reported by the study, released in draft form on January 19, 1987, was ultimately discovered to be due to the division of the reported number of cancer cases by a population statistic that understated the actual number of people living in the communities (thus inflating the rate of cancer incidence). The draft study specifically mentioned such incorrect population estimates as one potential source of error and called for a thorough search for other explanations before attributing the apparent excess cancer risk to environmental factors. Nonetheless, local media coverage presented the findings at face value. The resulting concern on the part of community residents led to speculation as to causes of the elevated incidence of cancer, with the local petrochemical industry being singled out for possible blame (Guidotti and Jacobs, 1993).

Guidotti and Abercrombie of the University of Alberta interviewed a group of civic leaders in the affected communities in order to determine their response to the incident. The group included 11 elected representatives, 9 local government administrators, and 7 other prominent individuals, including realtors. According to one senior official, “The public reaction was severe at first, and the news went right across Canada” (Guidotti and Abercrombie, 1994). Graphic media coverage at the national level continued for several months, confirming suspicions and reinforcing concern, even though no further evidence of increased risk was presented.

Several senior officials indicated that residents became “very concerned” as a result of the cancer stories, and that the community acquired “a reputation across the country as a ‘cancer city.’” Others painted a more placid response, but it is apparent that the cancer issue received a great deal of attention and was well known both inside the implicated communities and nationwide. A community survey taken shortly before the error was announced indicated that “residents of the affected communities...showed evidence of greatly increased concern for the safety of their communities and a perception of increased risk for health problems” (Guidotti and Jacobs, 1993).

Consideration of the (incorrect) findings of the draft study raises significant questions as to whether the noted elevations in cancer rates could truly have been caused by ambient environmental conditions or the presence of nearby petrochemical plants. With a few exceptions, the elevated rates were not statistically significant (at p=0.05) for specific sites. Instead, the results indicated an across-the-board elevation upon which chance variations were superimposed. The epidemiological findings did not fit patterns usually associated with occupational or environmental causes of cancer. Cancers most characteristically associated with chemical exposures, such as leukemia and cancers of the lung, bladder, and skin, were not strongly elevated (Guidotti and Jacobs, 1993).

Cancer rates in only two sites, the intestine and rectum in men, showed conspicuous elevations. These cancers are not among those associated with occupational or environmental exposures; rather they are linked to higher socioeconomic status and diet (Guidotti, 1992).

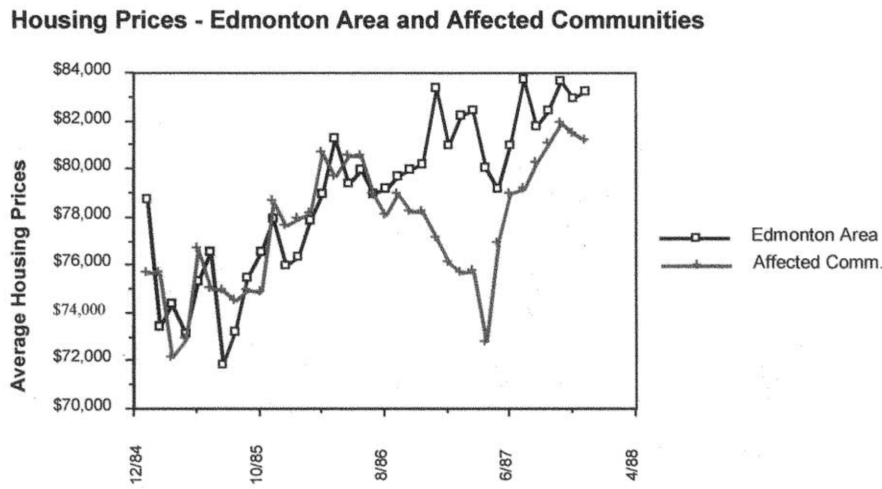
The long latency period of most chemically induced cancers also casts doubt on the implication of an imminent public health hazard. Most such cancers require periods of twenty years or more to develop. Cancer incidence trends currently evidenced would thus reflect exposures and lifestyle characteristics from the early 1960s, which would be very unlikely to have remained unchanged. It is thus quite likely that those risk factors would no longer be present (Guidotti, 1992).

Thus, even though the draft study provided no clear indication that simply living in the affected communities currently posed an increased risk of cancer, residents (and would-be home buyers) appeared to respond *as though* it did. The communities became associated with a heightened incidence of cancer, so that living in them appeared to entail an increased risk.

THE CASE FOR INTERPRETING THE DECLINE IN PROPERTY VALUES AS A UNIQUE RESULT OF THE CANCER SCARE

A significant result of this public concern was a decline in real estate values in the affected communities that coincided with the perception of increased cancer rates. It is the primary argument of this paper that this decline was due to the perception of increased cancer risk, and comprised a risk premium for living in the affected community. Prices began to decline in August of 1986 relative to a comparison communities, directly after the first public meeting addressing perceived increased cancer incidence. Prices continued to drop as the erroneous study was made public, and reached a nadir in April of 1987. The error was announced in May of 1987, and real estate prices rebounded rapidly thereafter to the levels found in surrounding communities. Figure 1 shows the trend in real estate prices. An analysis comparing prices of three-bedroom bungalow-style single family dwellings in the affected communities and in a reference community revealed that the perceived risk was accompanied by a decline in sale price of roughly $4000 or 5% of the house value (Guidotti and Jacobs, 1993).

The initial drop in real estate prices in August 1986 coincides with the aftermath of a local meeting with civic leaders held by investigators attached to the study. The investigators voiced concern over preliminary results and implied the possibility of a serious public health threat (Guidotti and Jacobs, 1993). In the months that



Source: (Guidotti and Jacobs, 1993)

Figure 1. Housing prices in the affected communities and Edmonton area.

followed, real estate prices in a comparison community continued the gradual rise of the previous 2 years, while prices in the affected community dropped. (See Figure 1.) The onset of the relative decline, the point of widest differential, and the timing of the rebound all follow the specific chronology of the incident (Guidotti and Abercrombie, 1994).

None of the civic leaders interviewed could identify a salient alternative explanation for the drop in housing prices (Guidotti and Abercrombie, 1994). According to one realtor, the cancer scare was a definite factor, both with regard to sales and to prices: "I personally lost the sale of three houses at the time of the scare and I hear everybody else in the business lost. Customers went to [a nearby community] which had some of the highest sales months then. They knew how to use the stories against us — I heard some realtors even carried the cancer stories in their sales folders." While some buyers were reluctant or unwilling to move into the community, sales were still consummated, implying that the decline in prices was due to a market response to the decline in demand for real-estate in the area (Guidotti and Jacobs, 1993). The lower prices did result in sales, with the price differential between the affected community and its neighbors acting as a risk premium for living in a place perceived to be more dangerous. This issue is explored in detail below, but first a framework is introduced for interpreting the price-risk tradeoff.

HEDONIC STUDIES AND THE VALUE OF LIFE

Hedonic wage and price studies comprise a branch of economics concerned with imputing valuations of commodities that are not sold on the market. The hedonic price approach has been applied extensively to residential housing and labor markets to evince indirectly market values for such attributes as air quality, neighborhood characteristics, quality of local schools and access to recreational facilities in the case of housing, and job safety in the case of labor markets (Pearce and

Markandya, 1989). Indirect methods are required for such studies because no market exists on which these attributes are bought and sold; rather they are 'traded' as elements of commodity bundles.

A. Hedonic Property Prices

The technique of hedonic property prices is based on the assumption that the value of residential property is related to the stream of benefits to be derived from it. In addition to the structural attributes of a home, attributes such as access to workplace, to commercial amenities and to environmental facilities, as well as the environmental quality of the area are also important determinants of value. The identification of a property price effect due to a difference in any one of the several determinants of value is usually done by means of a multiple regression using data from a large number of similar properties at a given point in time (Pearce and Markandya, 1989).

The procedure involves quantifying all relevant variables such that statistical analysis will isolate the differential valuations of each. This technique has been applied to studies of the willingness to pay for environmental quality, based on the assumption that individuals choose their level of exposure to air pollution through their choice of where to live. Residential housing prices will therefore include premiums for clean air, which the hedonic technique is intended to pick up (Freeman, 1985). Significant effects of air pollution on property values have in fact been found, revealing variations in values of a few percent over the range of pollution levels studied (Pearce and Markandya, 1989). However, these studies did not consider the risk to health posed by air pollution, and accordingly they provide no conclusion about the valuation of health risk as an endpoint of pollution.

By and large the application of hedonic price studies to the market for residential housing has focused on deterministic effects; even in the case of air quality, the studies have been concerned with the price effects of air pollution as an immediate nuisance, not with the resulting health risks. Hedonic price estimation can, however, be used to estimate *ex ante* valuations of risk, if the likelihood and severity of an adverse event are characteristic of a heterogeneous good such as housing, and if the purchasers are aware of this (Freeman, 1991). In such cases the location of housing impacts on the potential safety and well-being of the residents in a probabilistic way, as in the cases of possible earthquake damage, flooding, or, as is the concern here, cancer incidence. If individuals and the housing market are in equilibrium, the estimated (or actual) implicit price of risk reduction or premium for risk-bearing for each individual reveals that individual's *ex ante* valuation of risk (Freeman, 1991).

Thus, safety affects location decisions in much the same way as other attributes such as structural, neighborhood, and community characteristics. The key difference is that safety introduces a random element, as the outcome of concern may or may not happen at some point in the future (Brookshire *et al.*, 1985). When safety enters the location decision, it entails a decision about risk, and price differentials, which reflect such a decision, are valuations of risk.

B. Hedonic Wage and Risk Studies

Hedonic studies of occupational and product safety have extended the analysis to the valuation of risks to life, implicitly obtaining measures of the highly controversial concept of the value of life.[2] Wage risk approaches are similar to the hedonic price approach in that they seek to identify the value of safety from among a bundle of job characteristics. The wage rate paid for a job reflects forces of supply and demand in the market for labor. The job itself is a bundle of attributes, of which relative safety or degree of risk is one job characteristic. Other job attributes include working conditions, prestige, and training. If the market functions freely, such that workers can choose from a slate of differentiated jobs, then the wage rate can be expected to reflect the relative degree of job safety, other things being equal (Pearce and Markandya, 1989; Freeman, 1985). As workers can be expected to prefer less risk to more, jobs that entail higher risks of injury or death will need to pay higher wages to compensate workers for the greater likelihood and/or severity of harm.[3] Wage rates that are higher in risky situations entail a risk-premium for the greater probability of death or injury. Cross-sectional studies can thus be employed to reveal implicit valuations of risk reduction.

Estimates of consumers' willingness-to-pay for changes in the risk of dying can also be inferred from actual behavior in market situations involving risk-price tradeoffs. Hedonic regression techniques can be used for such purposes, making possible the extrapolation of value of life measures from the revealed preference of dollars versus risk (Atkinson and Halvorsen, 1990). One such example is the willingness to pay higher prices for automobiles in proportion to a reduction of the risk of fatal accidents. Atkinson and Halvorsen have extrapolated an implied value of life of approximately $3.36 million from a statistical analysis of automobile purchases (Atkinson and Halvorsen, 1990).

In general, indirect estimates of the value of life proceed from observations of risk-money tradeoffs. Because the market values safety, it must compensate consumers to bear marginal increases in risk. The value of life (VOL) measure thus follows from the simple expression

$$\text{VOL} = \frac{\text{Price or premium for change in risk}}{\text{change in risk}}$$

This is an admittedly crude measure, and is based on the assumption that the marginal rate of substitution of money for risk is constant, which is by no means a given. Nonetheless, value of life measures provide informative contrasts among choices made by individuals.

INTERPRETATION OF THE DECLINE IN PROPERTY VALUES AS A RISK PREMIUM

If the decline in the price of real estate in the communities affected by the cancer scare was in fact due to the perceived excess risk associated with living in the area, then a strong case can be made that the amount of the decrease represented a risk premium. As detailed above, there are very strong indications that the cancer issue was the sole driving force of the temporary declines in property values. It will be shown here that the rate of housing sales did not decline as a result of the cancer scare, and that a significant portion of the buyers consisted of people from outside the community. These factors strongly support the interpretation of the price decline as a risk premium.

That the decrease in housing prices compensated home buyers for the perceived increase in risk is indicated by the apparent lack of decline in the percentage of homes offered for sale in the affected communities that were actually sold, when compared with the rest of the Edmonton area. Figure 2 shows the trend in housing sales for 1987, the period of interest.

Recall that the erroneous report was leaked to the press in January of 1987, and that housing prices in the area reached a nadir in April of 1987. Interestingly, no decline in the rate of sales is evident when compared with the rest of the Edmonton area throughout this time period. While it is possible that fewer homes were offered for sale in the affected community during the scare, it appears that the price-risk tradeoff was sufficient to prevent a decline in the proportion of those homes actually sold.

Given that houses continued to be sold, it is still relevant to establish to whom they were sold. Moving from another community with a normal cancer rate into the affected community entailed a perceived increase in cancer risk. On the other hand, moving within the community did not. The risk premium interpretation of the decrease in housing prices is only valid for those home buyers who were moving into the community from without, because it was only they who were assuming an increased risk.[4]

There is reason to believe that people continued to move into the affected community even during the cancer scare. Although realtors are quoted above indicating that the perceived risk resulted in some lost sales, the fact that the rate of listed houses sold did not decline relative to the rest of the Edmonton area implies that the drop in price was sufficient to offset the risk. The demographic

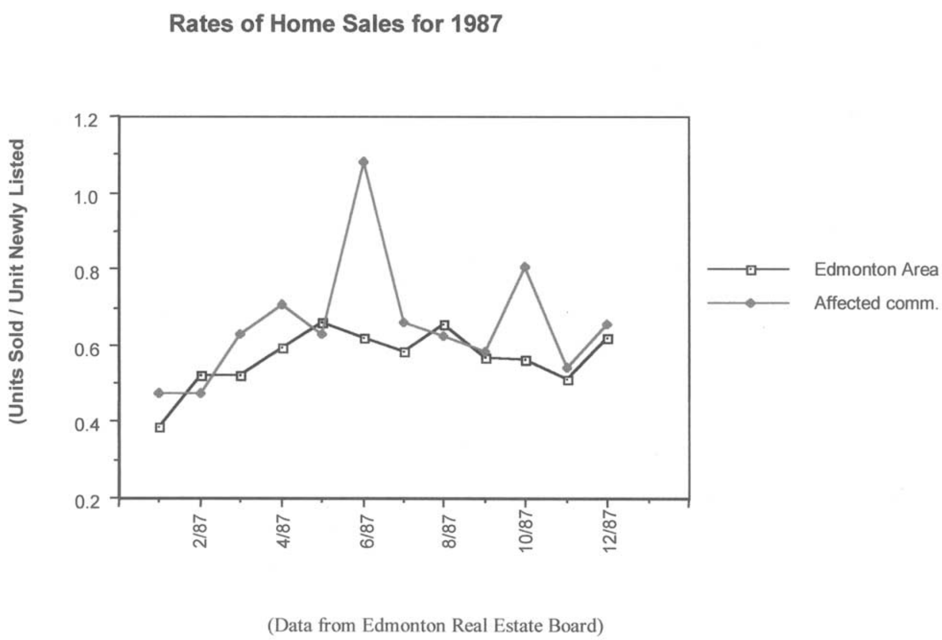


Figure 2. Rate of home sales for Edmonton area and affected communities for 1987 (# units sold divided by # of units newly listed).

profile of survey respondents shows that real estate transactions in the affected community have historically been more likely to result in moving into or out of the community than within it. Table 1 summarizes duration of residence information.

Taking the duration of residence in each time category to be 0.5, 3, 8, and 20 years, respectively, the weighted average of duration of residence in the current home is 9.5 years, while the average duration of residence in town is 11.9 years, consistent with findings of similar studies (USEPA, 1995). The closer the two numbers, the less people move within the community. This is because if people frequently moved within the community, then the average length residence in the current home would be considerably less than the length of stay in town. The opposite is the case here, indicating that most people stay in their original home for the duration of their residence in the community. This result, coupled with the apparent lack of decline in the rate of home sales during the cancer scare lend credence to the notion that people moved into the community in non-trivial numbers, accepting the perceived increase in risk.

The transient effect of the cancer scare on housing prices provides rare insight into the market valuation of increased risk. It is such insight that the technique of hedonic property prices attempts to capture, by way of statistical analysis. A major difficulty with hedonic techniques is that it is difficult to isolate the effects of any one of a multitude of attributes, which affect housing prices. The analysis usually relies on comparison of a large number of diverse properties at a point in time. Yet the issue of interest is how prices respond to a change in a specific attribute, all else being equal, so that statistical methods are required to filter out all other differences (Pearce, and Markandya, 1989). The goal is to arrive at valuations of a range of levels of a specific attribute, *as though* all other attributes were the same, and the difficulty in achieving this requirement results in a lack of accuracy.

The communities affected by the cancer scare provide a special, simplified case of what the hedonic technique tries to capture: property values responded to a change in the level of one attribute, notable cancer risk, not *as though* all other attributes remained the same, but *as* all other attributes remained the same. Put more formally, a residential property can be represented as a vector of attributes,

Table 1. Duration of residence in home and in town.

	Percent of Respondents	
Duration of residence (yrs):	in home	in town
< 1	8	6
1-5	35	23
6-10	25	25
10+	32	46

Source: Guidotti and Jacobs, 1993

including selling price, health risk, and all other characteristics (Freeman, 1985). Let P represent selling price, R represent ambient health risk, and Q represent all other attributes of the property. Then the value V of the property may be represented as

$$V = v(P,R,Q),$$

where v () is taken to be a multi-attribute value function.[5] Release of the cancer report resulted in a perceived increase in ambient health risk,

$$R' > R.$$

The market responded with lower property prices,

$$P' < P.$$

Because the proportion of listed houses sold did not decline relative to the rest of the Edmonton area, it appears that the *market valuation*[6] of the commodity bundles represented by residential housing did not change significantly. That is to say,

$$v(P,R,Q) \approx v(P',R',Q).$$

Because an increase in the perceived risk of cancer is clearly undesirable all else being equal, the decline in house prices should be viewed as a compensating variation, or risk premium. In this case, then, the compensatory market value of the perceived increase in cancer risk was $4000 on average. This is admittedly an average value, but one that can be taken to give a good central measure of the premium demanded by homebuyers. This claim is supported by two factors. First, there was no decline in the percentage of listed homes that were sold during the period of the cancer scare relative to the rest of the Edmonton area. Second, the dynamics of the housing market do not necessarily allow the seller to sell to the highest bidder. Sellers receive bids in sequence and have to either accept or reject them (Pearce and Markandya, 1989). Thus the $4000 risk premium represents expectations of the market, based on perceived market conditions. As sales did not appear statistically to drop, the decline in housing prices was sufficient to compensate enough buyers to maintain demand, lending support to the notion that the $4000 risk premium was well within the range of what the market would support.

INTERPRETATION OF THE RISK PREMIUM AS A MEASURE OF VALUE OF LIFE

The most provocative interpretation of the risk premium entailed in the reduction in housing prices is as an implicit measure of the value of life. This value has been imputed from the willingness-to-pay and willingness-to-accept for small changes in the probability of death in contexts such as wage-risk and contingent valuation studies. The U.S. Environmental Protection Agency's (USEPA's) 1997 retrospective benefit-cost analysis of the Clean Air Act uses a distribution of 26 mortality valuation estimates (Viscusi, 1992) to assess the value of life (USEPA, 1999). The distribution of these estimates ranges between $600,000 and $13.5 million in 1990 dollars, and was fit to a Weibull form with a mean of $4.8 million and a standard deviation of $3.24 million. All of these values are obtained from the simple expression

$$\text{VOL} = \frac{\text{Price or premium for change in risk}}{\text{change in risk}}$$

The reduction in housing prices represents a price premium for change in risk. Assuming that the background rate of cancer in Alberta is 25%[7] the 25% increase over that would result in an incremental increase in risk of

$$0.25 * 0.25 = 0.0625, \text{ or } 6.25\%.$$

This is a very significant increase, on the order of 6×10^{-2}, a level that is four orders of magnitude higher than the 10^{-6} bright line in making regulatory determinations that is frequently cited.[8]

Two other factors remain to be established before a value of life measure can be imputed. First is the number of people per house. This is relevant because the risk premium applies per house, not per resident, while each person living in the house would be exposed to the (phantom) excess risk. The second issue concerns the assumed survival rate for cancer. The end-point of interest for the value of life is, ironically, death, so that excess cancer cases need to be converted to excess deaths. Table 2 presents value of life measures over a range of these factors.

These values are strikingly low. Assuming three people per house and a generous 50% cancer survival rate yields a value of life measure of less than $43,000, less than even the rock-bottom low-end valuations from existing studies in the literature.

Because lives are never really saved, merely prolonged or foreshortened, another measure of merit is the value per life-year lost. Following the convention in Graham and Vaupel (1981), victims of cancer death may be taken, on average, to lose 16 years of life. The distribution of this measure as a function of occupants per house and cancer survival rate is shown in Table 3.

Table 2. Imputed value of life in dollars based on risk premium for excess cancer incidence.

	Cancer survival rate				
People/house	0.1	0.3	0.5	0.7	0.9
2	35556	45714	64000	106667	320000
3	23704	30476	42667	71111	213333
4	17778	22857	32000	53333	160000
5	14222	18286	25600	42667	128000

Table 3. Imputed value per life-year lost in dollars based on risk premium for excess cancer incidence.

	Cancer survival rate				
People per house	0.1	0.3	0.5	0.7	0.9
2	2222	2857	4000	6667	20000
3	1481	1905	2667	4444	13333
4	1111	1429	2000	3333	10000
5	889	1143	1600	2667	8000

If one believes that home buyers made a calculated decision based on their perception that they incurred an additional 6×10^{-2} (or 6.25%) risk of contracting cancer as a result of living in one of the affected communities, then with three people per house and a 50% survival rate, the imputed value per life-year lost is less than $2700. This implies that the home buyers would have been indifferent between a choice of $2700 or an extra year of life, a somewhat surprising result. Although the years of life lost are assumed to be at the end of life and consequently in the future this calculation is carried out without discounting. A similar calculation performed on the Viscusi data set (1992) yields a value per life year lost of about $300,000.

The value of life measures imputed from the reductions in housing values are extremely low; they are one to four orders of magnitude below similar results obtained from other examples of risk-dollar trade-offs. Because the differences are so large, it is unlikely that they can be attributed to the assumptions inherent in the analytical process for deriving the risk premium. For example, doubling the risk premium still yields remarkably low value of life measures. These results, however, do rest on the assumption that would-be home buyers were aware of the reports of increased cancer risk *and* found these to be credible. As described in Section 2 these assumptions appear to be valid. A corollary assumption is that those moving into the communities would come to face the same cancer risk as those already living in the communities. While there is ample evidence that living in the communities was perceived to be associated with an elevated cancer risk, it is unknown how this perception was correlated with the duration of residence. Assuming that the elevated rates of cancer reported by the study were correct, one would expect that rate to be associated with the average length of stay in the community — or 11.9 years, as discussed above — which is considerably shorter than a statistical lifetime.

A definitive reason for the disparity between value of life measures derived from home purchase decisions in this case and similar VOL measures reported elsewhere is not likely to be forthcoming, but possible explanations are worth exploring. One potentially significant difference between this case and other studies from which value of life measures have been imputed is that the risk for which a premium is received is about two orders of magnitude greater here. The perceived risk from the purported increased cancer incidence was about 6%, or 6×10^{-2}, while most of the studies cited above involved risks on the order of 10^{-4} to 10^{-3}. The extrapolation of the value of life measure from risk-dollar trade-offs is based on an assumption of a constant marginal rate of substitution between the two. That is to say, if $5000 compensates for a 1% increase in the risk of death, then $50,000 compensates for a 10% increase, and the value of life measure is ten times that, or $500,000. Individual studies tend to reveal the trade-off between only one particular risk and one particular dollar amount, so a cross-section of these studies provides only point estimates of the value of life, based on the specific degree of risk encountered.[9]

This case yields a value of life measure from a risk-dollar trade-off involving a much greater risk than that encountered in other studies. The results suggest that the marginal rate of substitution in risk-dollar decisions cannot be assumed to be constant and independent of the probability of harm at issue, and should raise suspicions about the practice of comparing value of life measures obtained from situations involving widely disparate magnitudes of risk. Indeed, Pearce and Markandya's review of the literature suggests that low probabilities of death are associated with high values of life (Pearce and Markandya, 1989). It follows that high probabilities of death, such as the one encountered here, are associated with low values of life. This is certainly the case here.

These results imply that an individual's valuation of risk is based on more than a numerical measure of the likelihood of adverse effects.[10] Thus, it may be more appropriate to refer to the reduction in housing prices as a fear premium; one that is received in exchange for a perceived increased chance of developing cancer, but one that is not necessarily based on something nearly as rigorous as an expected utility analysis. The finding that low probabilities of death are associated with high values of life, coupled with the results here, imply that many individuals make decisions with regard to risk with reference to the existence of some possible harm more than the likelihood of that harm. This conclusion is supported by research that indicates that decisions involving low probability events differ from decisions made with regard to higher probability events by amounts that are not consistent with the differences in probabilities (Magat *et al.*, 1988). These results suggest that the aversion to a risky situation may properly be decomposed into a component that is due to the mere presence of a particular type of hazard, and one that increases with the likelihood of harm due to that hazard. This sort of a construction would help explain the increase in imputed value of life measures with decreasing probabilities of death. And, in this way, the risk premium may be viewed at least in part as a fear premium, compensating for the very existence of a hazard. In addition, one's level of aversion to risk and the associated risk premium are likely to vary according to the type of hazard faced.

CONCLUSIONS

The natural experiment documented here, a transient cancer scare and the resulting effects, presents a possibly unique opportunity to impute risk-valuation measures from hedonic property prices. Hedonic studies have traditionally sought to extract the valuation of certain non-market attributes of residential property and jobs by way of statistical analysis of prices and attributes. These studies have attempted to treat specific characteristics *as though* all others were equal. The necessary and somewhat arbitrary assignment of value to intangibles and the complexity of the analysis required have limited the accuracy of these studies. The case discussed here is unique in that it allows the valuation of risk to be extrapolated in a situation where all else *was* equal.

The resulting analysis yields value of life measures that are extremely low compared with those imputed in other studies, on the order of $50,000. It is unlikely that these measures accurately reflect the preferences of home buyers; for example, it is doubtful that many would be willing to trade $2700 for a year of their life, even though this is what the analysis implies. These results cast doubt on the validity of the assumption of constant marginal rate of substitution of money-risk trade-offs, which is the basis of the technique of imputing value of life measure from money-risk decisions. However, relaxing the assumption that all residents knew about and believed the reports of increased cancer risk would increase the VOL estimated herein.

This caveat notwithstanding, the results further imply that the probability of adverse events affects the *marginal* rate of substitution of money for risk. The events here involve a perceived risk in the neighborhood of 6×10^{-2}, which is two to three orders of magnitude greater than the risks on which other studies are based. The marginal valuation of risk (and therefore of life) is much greater in studies involving a low probability of death than in this case. One representation of this result involves decomposing the aversion to a risky situation into a constant component that is in response to the mere existence (or awareness) of a hazard, and one that varies with the likelihood of the harm.

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FOOTNOTES

1. For an excellent detailed description of the events surrounding the epidemiological error, see (Guidotti and Jacobs, 1993).

2. For a lively discussion, see (Broome, 1978; Buchanan and Faith, 1979; Jones-Lee, 1979; Williams, 1979).

3. Of course this is not always true, as in the case of fire fighters or marines. For purposes of analysis, occupations that derive part of their attraction from the excitement entailed by risky activities are poor sources of risk-valuation information. This caveat does not detract from the argument that follows, because it is highly unlikely that the excitement of living in a community with a high incidence of cancer imparts any sort of enjoyment on residents.

4. It could be argued that those who sold their homes and moved out of the affected communities accepted the decrease in property value relative to similar communities as a price of decreasing their risk. In that case the decline in property value is a lower bound on their willingness to pay for decreasing risk, because by virtue of the fact that they took the decrease they were willing to accept at least that much of a decrease. However, it is tenuous at best to establish that people in the affected communities sold their houses expressly to move into an area with less perceived risk, so discussion is focused on those who moved into the area, not out of it.

5. A value function is indicated instead of a utility function in keeping more with the terminology of decision theory than classical economics. Within this nomenclature, a multi-attribute value function encodes a decision-maker's preference over a bundle of commodities, whereas a utility function encodes the decision-maker's risk posture. Risk posture here is simply a measure of preference for certain vs. uncertain outcomes.

6. Application of a single multi-attribute value function to encode the preferences of more than one decision-maker presents theoretical difficulties. At the

risk of sacrificing some amount of rigor, it is assumed here that the vector of attributes for which the market clears represents an average, or market, valuation of the commodity bundle.

7. Note that this is a conservative estimate vis a vis our calculations, as background cancer incidence in the United States has been estimated at levels as high as one in three lifetime. Use of a higher background incidence of cancer would result in a greater increase in perceived risk in the affected communities, and therefore an even lower measure of the value of life.

8. Reflection on similar incidents, such as Times Beach and Love Canal, would lead one to believe that if causality had ever been established in this case and the increased cancer risk confirmed, then the communities affected by the increased risk would most likely have been condemned and evacuated. Such an outcome would have had an even more pronounced effect on housing prices.

9. If, however, erroneous epidemiological studies claiming a range of increases in cancer incidence were released concurrently in a variety of distinct communities, then a demand curve could be arrived at from the resulting declines in property values. This option, however, presents obvious ethical difficulties.

10. This is especially true since many individuals simply do not have a quantitative representation of a risky situation. For example, it is quite likely that very few would-be homebuyers considered the prospect of 16 life years lost from cancer on average, or were even aware of the figure.